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Blowin' in the Wind

Who has seen the wind?
Neither you or I:
But when the trees bow down their heads
The wind is passing by.

—Christina Rossetti

The invisible elusive wind has long served and defied the human race. The mystique surrounding the wind encompasses tales of mystery, enchantment, and adventure.

Ancient Greeks and Romans believed the winds were the children of the earth and the sky. Wizards in Finland sold wind—tied up in a rope with three knots—to sailors. Some people in West Africa still believe that a wind god named Bagba keeps the winds shut up in great pots and lets them out when he pleases.

Humans must catch the wind before they can harness it. Thousands of years ago, people first caught the wind to push sailboats—prototypes of the magnificent windjammers. Inhabitants of Babylon and Persia were probably the first to use windmills. A common power source in Europe in the late 1700's, windmills became so popular they are the national symbol of The Netherlands.

Millions of windmills and wind turbines were built in the United States between 1880 and 1930. With the advent of rural electric power, however, once-proud windmills stood unused, in disrepair.

Now, we must find alternative energy sources. Wind energy has many agricultural applications and the power system is relatively simple. Since the technology for harnessing the wind is simple, safe and, in some cases, already developed, wind may soon become a significant power source.

In conjunction with the Energy Research and Development Administration, ARS is now seeking the best ways for agriculture to use wind energy. Such projects as using wind power to heat rural houses and pump irrigation water, will be studied. How much agricultural energy can be exploited from the wind and where it is most feasible are research questions.

Because the wind is capricious, we cannot depend on it where we need constant power. Storage may not be economical. But, wind energy can be used with fossil fuel or other sources to assure a constant power supply.

The answer to many of our agricultural energy problems may, in fact, be "blowin' in the wind."—*M.M.M.*

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AGRISEARCH NOTES

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COVER: Air-inflated solar collector. Each bag is 100 feet long; together they have a volume of 2,500 cubic feet per minute airflow. The system is powered by a 1-horsepower ventilation fan (0175 X 60–22A). Article begins on page 10.

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Talcott W. Edminster, Administrator
Agricultural Research Service

Processing Alfalfa with Less Fuel

Dr. Kehr examines windrowed alfalfa for stage of maturity and insect and disease damage. The windrower in the background mows the alfalfa and piles it in windrows for partial drying in the field (0876X1033-10A).

THE DEHYDRATION INDUSTRY is conserving energy in producing alfalfa pellets, thanks to research begun a decade before the energy crisis.

University of Nebraska and ARS scientists in 1965 demonstrated that fuel use for dehydration could be reduced, with no appreciable loss in pellet quality, if the alfalfa were first partially dried in field windrows. Protein, carotene, and fiber contents of pellets processed after moisture was reduced to 60 percent in the windrow, from 78 percent, were not appreciably different from those of pellets from direct-cut alfalfa.

These results attracted minimum attention when natural gas and oil for dehydration were readily available and inexpensive. Today, many dehydrators have shifted to partial windrow drying on a part-time or full-time basis. They are producing pellets of acceptable quality while reducing natural gas consumption 10 to 20 percent, according to industry estimates.

More than 90 dehydration plants in Nebraska, each processing alfalfa from

about 5,000 acres, produce about 45 percent of the dehydrated alfalfa in the United States.

In partial field drying, alfalfa is cut with a windrower and allowed to wilt to about 60 percent moisture. Then it is harvested by chopper with pickup attachment and dehydrated. Less fuel is needed and total output is increased because of less time in the dehydrating drum. Chopped alfalfa in the field has a moisture content of 75 to 80 percent, while that of the pellets is from 5 to 6 percent.

University biochemist Robert L. Ogden and ARS agronomist William R. Kehr (333 Keim Hall, University of Nebraska, Lincoln, NE 68583), continued their studies to define conditions under which partial windrow drying would be successful. Wind speed, amount of sunshine, air temperature, and humidity all affect drying rate in the windrow.

Tests on four successive days each in June, July, August, and September showed that wilting alfalfa in the windrow removed 3,000 to 4,000 pounds of water per ton of hay in 9 daylight hours with favorable weather. Alfalfa was not dried below the desired 60 percent moisture level unless moisture content of uncut hay was less than 75 to 77 percent.

Protein content did not change significantly with up to 10 hours of field

Above: An alfalfa chopper with a windrow pickup attachment picks up alfalfa after partial field drying. The chopper is a highly adaptable piece of farm machinery that can be altered to serve a variety of purposes (0876X1034–19A). Right: Trucks loaded with partially field-dried chopped alfalfa wait to unload at a dehydration plant. Partial field drying reduces the amount of fuel needed for dehydration (0876X1033–16A).

drying, these tests indicated. Carotene content of full-bloom, first-cutting hay declined significantly after 4 hours but did not change significantly in the other three cuttings with up to 10 hours of field drying.

Another study compared drying in windrows made at 1 p.m., 7 p.m., 1 a.m. and 7 a.m. Drying to 60 percent moisture was achieved, after 8 to 9 hours, only in two June tests begun at 7 a.m., although a similar amount of water was removed from alfalfa with higher initial moisture content in other tests. Drying rate was very low during night hours; hay sometimes picked up moisture from dew accumulation at night.

In feeding trials conducted by Nebraska animal scientists Cecilia Dorn and Terry J. Klopfenstein, Mr. Ogden, and Dr. Kehr, pellets made from partially field-dried alfalfa proved equal to those from direct-cut alfalfa. Tests were run with 12 and 24 wethers and with 192 steers. Dry matter, nitrogen, and fiber digestibilities were equal in the two types of pellets, and both were rated excellent sources of protein and digestible dry matter.

The researchers caution that dehydrating field-wilted alfalfa must be carefully controlled to yield a quality product, since less heat and time are required than in processing direct-cut alfalfa.—*W.W.M.*

Above: *After unloading, the chopped alfalfa moves through the autofeeder, drawn by an endless chain, into the dehydration drum for processing into pellets (0876X1032–31).* ***Left:*** *Bill A. Malone, a dehydration a cooperating biochemist from the University of Nebraska, examine freshly extruded alfalfa pellets (0876X1033–35A).*

Beef cattle genetic resources — A long look

THE WIDE SPECTRUM of beef cattle types available in the world gives cattlemen the opportunity for matching genetic resources with specific production and marketing requirements—provided the strengths and weaknesses of each cattle type are known.

ARS, in cooperation with the University of Nebraska, Lincoln, is developing information needed for wise use of these genetic resources through the long-term beef germ plasm evaluation program at the U.S. Meat Animal Research Center (P.O. Box 166, Clay Center, NE 68933).

The program's objective, says Director Keith E. Gregory, is to characterize, in breed crosses or breeds, the biological and environmental relationships among traits relating to growth, feed-use efficiency, carcass composition, meat quality, and reproduction.

In the first cycle of the study, a team of USMARC scientists bred Angus and Hereford cows by artificial insemination to 200 sires representing seven breeds—Angus, Charolais, Hereford, Jersey, Limousin, Simmental, and South Devon. Cows were 2 to 3 years old at the start of the study. More than 2,300 calves were produced in three seasons. Steers were fed out and slaughtered and heifers raised to maturity and bred.

Charolais and Simmental crosses had higher preweaning average daily gains, were heavier at weaning, had larger birth weights, and more calving difficulty than the other breeds. South Devon and Limousin crosses were similar to Hereford-Angus crosses in weaning weight, intermediate in birth weight, and more like Charolais and Simmental crosses in calving difficulty. Jersey crosses were lightest at birth and weaning and had the least calving difficulty.

In the feedlot, Charolais and Simmental cross steers, followed by South Devon crosses, were largest at 405 days of age and fastest gaining. Hereford-Angus and Limousin crosses were similar in weight; Jersey-sired steers were smallest and slowest gaining.

The researchers computed feed-use efficiency of about 1,100 steers three ways.

At 5 percent ribeye fat, which was approximately equivalent to low choice quality grade, Hereford-Angus steers were the most efficient but not significantly different from South Devon, Charolais, and Jersey crosses. Limousin crosses were least efficient but not significantly different from Simmental-sired steers.

Efficiency of gain during 217 days on feed showed an advantage of faster gaining over slower gaining groups in spite of the heavier weights maintained. By this measure, Charolais cross steers were most efficient and Jersey crosses least.

Computing efficiency in terms of feed needed to increase weight from 530 to 1,035 pounds favored breed groups farthest from mature size because of leaner composition of their gain. On this basis, Charolais crosses were significantly more efficient than all other groups except Simmental, and Jersey crosses were least efficient.

The steers were slaughtered and graded at a commercial packing plant, and the right side of each carcass was processed at Kansas State University, Manhattan, to obtain detailed information and taste-panel palatability evaluation.

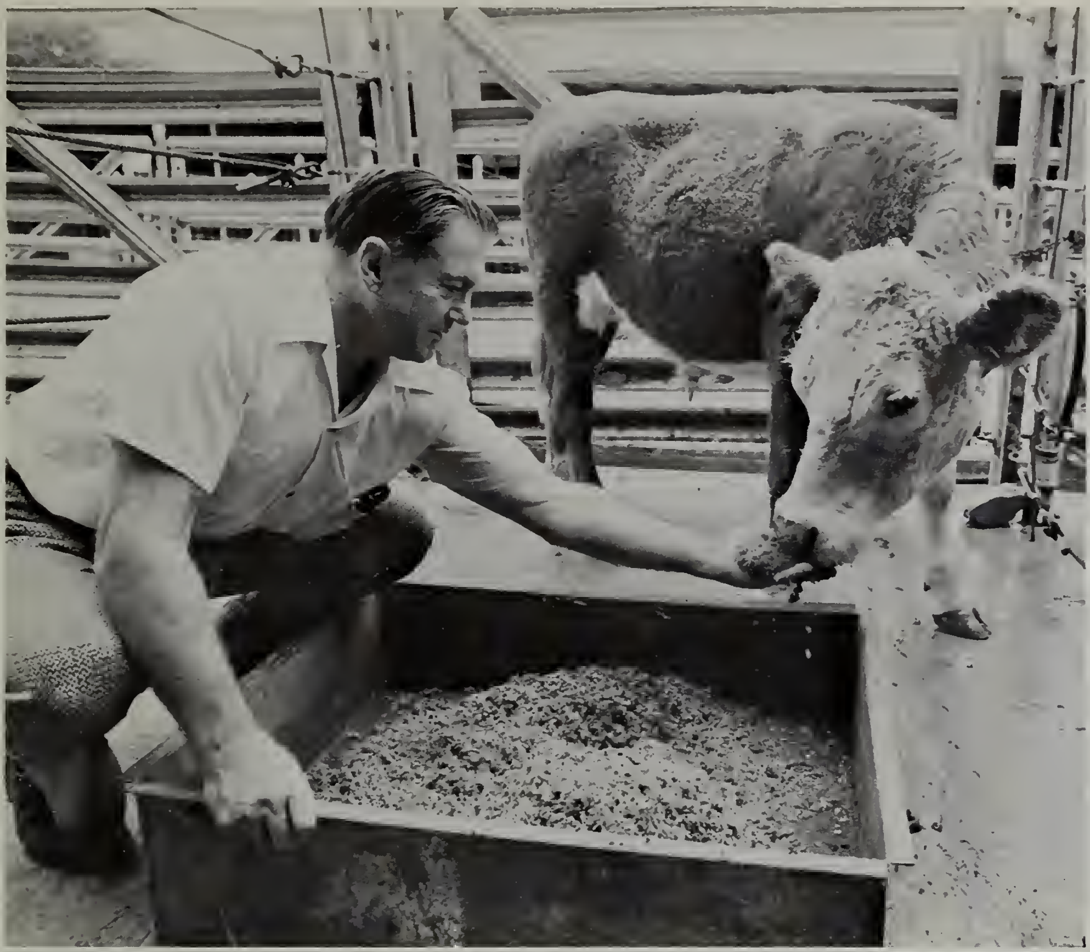
Charolais, Limousin, and Simmental crosses had a significantly higher percentage yield of prime cuts and lower percentage of fat trim. South Devon and Hereford-Angus groups were intermediate, and Jersey crosses lowest.

Jersey crosses were significantly higher than the other breed groups in marbling (estimated amount of intramuscular fat in the ribeye). They were followed in rank by Hereford-Angus, South Devon, Simmental, Charolais, and Limousin.

Palatability of rib steaks from the carcasses, as scored by an experienced taste panel, was well above the minimum acceptability for all breed groups, and differences were small.

In the evaluation of growth of 945 heifers, Charolais, Simmental, and South Devon cross heifers were heaviest at 400-day age, followed closely by Hereford-Angus and Limousin. Jersey crosses were lightest.

Limousin and Charolais cross heifers were oldest when they reached puberty; Hereford-Angus, South Devon, and Simmental crosses were intermediate; and Jersey crosses were youngest. Breed of dam had a large effect in favor of Angus dams on percentage of heifers reaching puberty between 270 and 510 days of age. Fewer heifers from 2-year-old mothers reached puberty at 390 days, and the percentage rose as age of dam increased.—*W.W.M.*



Research technician Banner L. Phillips demonstrates that the steers involved in the cottonseed-hull feeding studies readily eat the test product—even to the extent that they can be handfed (0976X1219–34).

Another source of roughage

COTTONSEED HULLS make a good source of roughage for winter feeding of cattle. The hulls, a byproduct of cotton ginning, are readily eaten by cattle and provide about 45 percent digestible energy in the diet.

In experiments at the Beltsville Agricultural Research Center, growing steers were fed diets containing various combinations of 100 percent crude protein equivalent supplements. Their supplements contained biuret or urea as the nonprotein nitrogen (NPN) sources. In two diets, part of the nitrogen in the NPN was replaced with natural proteins in the form of either soybean meal or fishmeal. Steers on all diets were fed cottonseed hulls, minerals, and vitamins free-choice.

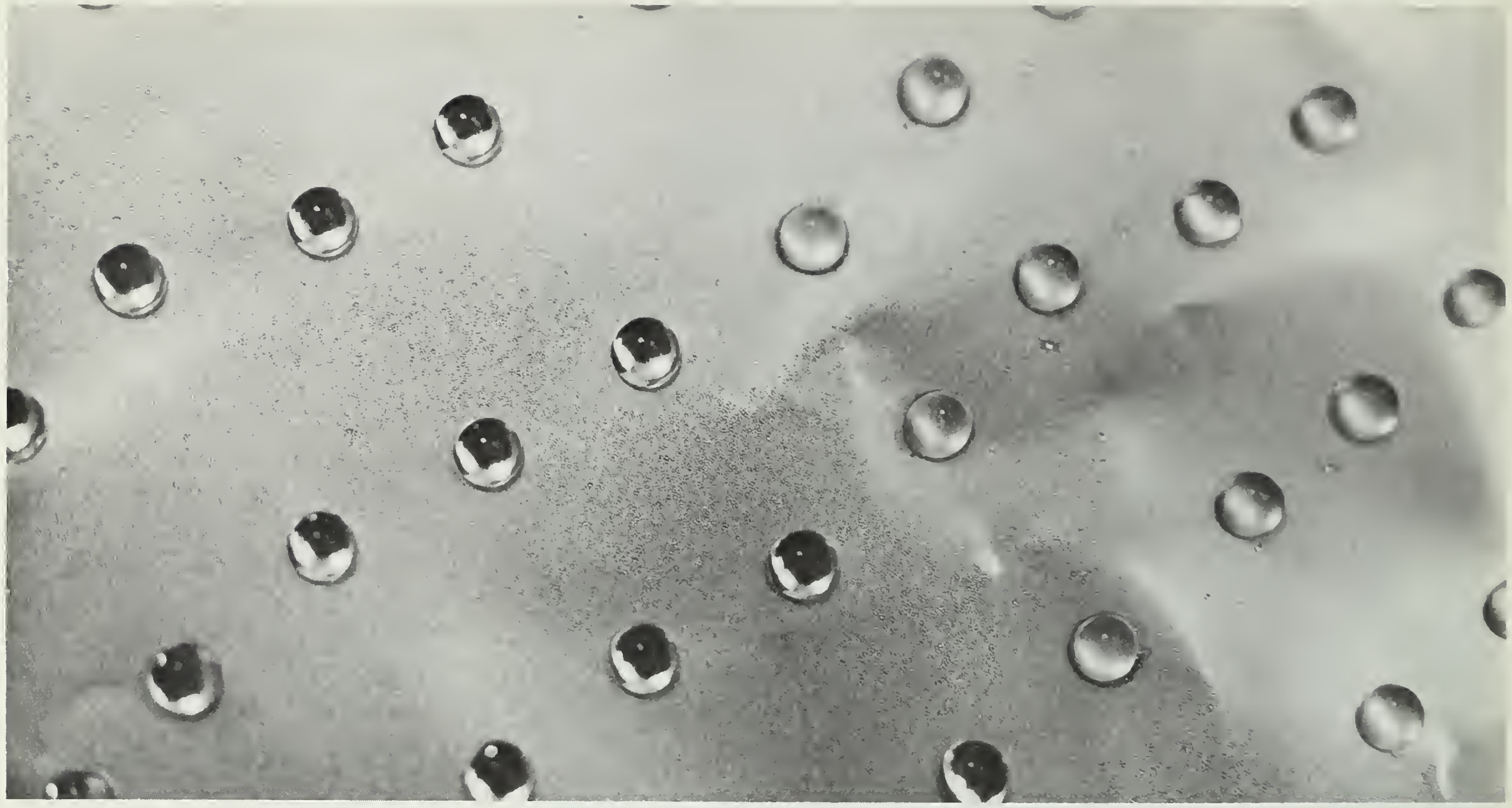
The trials were conducted by ARS animal scientists Robert R. Oltjen, David A. Dinius, and H. Keith Goering (Building 200, ARS–East, Beltsville, MD 20705).

When steers were fed only biuret or urea as the NPN source, they gained 1.2 pounds per day. However, when a small part of the nitrogen in the NPN was replaced with fishmeal or soybean meal, steers gained about 1.5 pounds per day. Adding soybean meal or fishmeal encouraged cattle to eat the cottonseed hulls. Cattle ate about 3.1 percent of their body weight in cottonseed hulls per day. Adding monensin, a rumen stimulant, to the diet decreased the intake of cottonseed hulls and reduced gains.

These experiments were repeated, substituting chopped cornstalks or barley straw for cottonseed hulls in two diets. Steers fed cornstalks lost weight and consumed only about half as much as did steers fed cottonseed hulls. Steers fed barley straw fared slightly better than cattle fed cornstalks—gaining about 0.4 pound per day—but ate only two-thirds as much as cattle on cottonseed hulls.

Cattle fed cottonseed hulls gained at or above the 1–1.5 pounds per day often recommended for overwintering of steers. "These results indicate," says Dr. Oltjen, "that it is feasible for cattlemen to winter their steers on diets containing cottonseed hulls as the sole roughage source, supplemented only with NPN, vitamins, and minerals." —*M.E.N.*

Cottonseed hulls—a low-quality roughage that is a natural byproduct of cotton production—are being used as the primary energy source in the rations of more than 100 beef steers in two separate studies at Beltsville (0976X1219–15).



The droplets on the left, which contain no bacteria, are super-cooled, fluid water. Those on the right, which contain bacteria active in ice-nucleation, have frozen (0676X799–9).

Bacteria linked to frost damage

A DISCOVERY about bacteria on plant leaves may lead to technology for reducing the gamble that farmers take in northern States as they try to produce corn and other crops profitably between late spring and early fall frosts.

In the course of basic studies on nature of disease resistance in plants, an ARS scientist observed striking differences in frost damage between laboratory-grown corn seedlings that had been treated with leaf powder containing bacteria from field-grown corn and seedlings that had not been so treated. From field-grown plants, the researchers isolated bacterial species that can act as nuclei in the formation of ice crystals on plants.

The finding may signal a quest for economical ways to control populations of ice-nucleation-active (INA) bacteria on corn and other crops. While commercial application of the research may be years away, the study is an example of work that could reduce crop losses.

ARS chemist Christen D. Upper (Disease Resistance Laboratory, University of Wisconsin, Madison, WI 53706), and his colleagues Steven E. Lindow and Deane C. Arny at the University of Wisconsin, placed corn seedlings grown to the three-leaf stage into a controlled-temperature chamber where, over a period of an hour or longer, temperatures dropped from 0° to −3.5° C or lower. Then, in a period of more than one-half hour, temperatures rose to 30° C. Less than 10 percent of bacteria-free leaves sustained frost injury unless temperatures dipped lower than −8° C (18° F).

On other seedlings, the researchers sprayed buffered suspensions of an INA bacterium, *Pseudomonas syringae*, in concentrations of about 1 billion cells per milliliter (ml). The next day, exposure of the seedlings to a −4° C environment resulted in damage to nearly all leaves. Scientists observed similar damage in the field after temperatures fell into a −2° to −5° C temperature range.

The scientists have discovered that at least one other bacterial species that lives on corn leaves, *Erwinia herbicola*, is an active ice nucleus. Both species are called epiphytes because they reside on plant surfaces and depend on plants for sustenance and growth.

P. syringae also is a pathogen and can invade a wide variety of plants throughout the world, sometimes causing yield losses in crops. Until now, however, the organism was thought to have little impact on corn production. Consequently, researchers who developed inbred lines of corn and corn hybrids did not give major attention to resistance of corn to holcus spot, the corn disease caused by *P. syringae*.

Moisture may enhance *P. syringae*'s growth or movement to sites on plants that are vulnerable to frost damage, says Dr. Upper. His studies show that, in the laboratory, *P. syringae* suspensions as dilute as 150,000 cells per ml cause frost to damage 75 percent of corn leaves if sprayed plants are held under a mist for 24 hours before they are exposed to a −4° C environment.

In another experiment, the scientists reduced INA bacterial populations in the field by spraying corn with dilute solutions of the antibiotic, streptomycin. Several days later, in the first light frost of the fall, the temperature dropped to about −2° C. About 13 percent of the sprayed leaves were frost damaged compared to about 29 percent of the leaves that were not sprayed.

Streptomycin is toxic to corn plants and is not registered for use on corn. Furthermore, spraying complete fields with the antibiotic would be expensive. However, the scientists hope other ways can be found to change the environment of leaves to reduce populations of bacteria that incite frost damage.

In studies that were less extensive than those on corn, researchers observed that frost sensitivities of lettuce, green beans, tobacco, and tomatoes also may be conditioned by populations of INA bacteria on leaf surfaces. The potential economic impact of controlling the bacterial pests is difficult to assess, says Dr. Upper. Precise information of actual losses from frost on most crops is not available.

The average corn yield for the United States in 1974 was down 20 bushels per acre from the previous year, due in large part to early fall frosts. In Wisconsin alone, corn growers received some $10 million in disaster relief because of the frost damage.—*G.B.H.*

Left: *University of Wisconsin graduate student Steve Lindow—with Dr. Upper observing—applies droplets of bacterial suspension to aluminum foil floating on a −5° C constant temperature bath. This allows researchers to compare the relative freezing characteristics of each suspension (0676X798–19).* ***Right:*** *Mr. Lindow compares young corn after it was subjected to −4° C. Prior to freezing, the undamaged corn was treated with plain water. The damaged corn was treated with a suspension of bacterial ice nuclei (0676X798–5).*

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The Pon Ponder farm in Tuscola, Ill., is the site of one of several solar projects near the Champaign-Urbana area. In photo on right, Dr. G. C. Shove, professor at the University of Illinois, checks the temperature of the air as it enters the solar collector (0175X53-5) and, above photo, as it leaves the collector and enters the drying fan (0175X56-27A). The drying fan forces the solar-heated air into the drying bin. These data enable researchers to compute temperature rise through the solar bag. The capacity of the bag is 2,000 cubic feet per minute, and it is capable of generating 60,000 Btu's per hour on a sunny day.

Harnessi

FARMERS have always depended on solar energy, directly or indirectly, to dry their mature crops. The new dimension in solar drying is collecting and directly using solar energy to dry corn, rice, and occasionally grain sorghum, wheat, or soybeans at the time of harvest.

Supplemental solar heat speeds low-temperature drying of grain in the bin, says ARS agricultural engineer George H. Foster, and increases the probability that drying will be completed before the onset of winter weather. The feasibility of applying solar energy to high-speed batch or continuous flow grain drying is yet to be determined.

Letting the sun and wind dry crops standing in the field, in the stack or windrow, or in a ventilated crib or shed is in fact solar drying, he points out. Earlier harvest of corn at higher moisture content, as the picker-sheller replaced the corn picker over the past 20 years, has increased the farmer's dependence on fossil fuels, principally LP and natural gas. These fuels are solar energy that growing plants of the past concentrated by photosynthesis.

Mr. Foster, at the U.S. Grain Marketing Research Center (1515 College Ave., Manhattan, KS 66502), says the energy now required for drying corn often exceeds the energy for producing the crop, from seedbed preparation through harvesting. The proportion of the corn crop artificially dried in Illinois, Indiana, and Iowa rose from 14 percent in 1956 to around 70 percent in the 1970's.

Grain has been solar-dried to moisture levels safe for storage, without significant spoilage, in about two dozen tests at eight Corn Belt locations. This research was funded by the Energy Research and Development Administration and the National Science Foundation.

Mr. Foster is coordinating the research in association with agricultural engineer Robert M. Peart, Purdue University, West Lafayette, Ind. Field tests or computer simulation studies were done by land-grant universities in Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, and South Dakota. Ad-

Above: The cover plate of the solar collector being used in this cooperative experiment at Iowa State University (ISU), Ames, unlike those at Champaign and Manhattan, is not an inflated air bag. It is a rigid structure made of acrylic plastic (0175X38–30).

Left: ARS technicians at Manhattan, Kansas, emerge from the storage bin connected to the solar dryer after probe sampling at given depths and locations in the bin. These samples are used to determine moisture content and storage mold invasion (0175X61–29).

g the Sun

ditional research was done by an Arizona firm and by ARS agricultural engineers in Indiana, Iowa, Kansas, and Texas.

Solar heat is most promising for low-temperature drying in the warmer, more humid parts of the Corn Belt, Mr. Foster says. There, heat is needed to lower humidity so drying can proceed to a moisture level safe for storage. Low-temperature drying can be completed without supplemental heat most of the time in less humid areas, such as Kansas. On the other hand, he says solar energy may not furnish enough extra heat to assure drying success in northern locations.

How fast solar drying is adopted will depend on the supply and price of fossil fuels and also on how much of a scarce supply is available for agricultural production, Mr. Foster points out.

In comparison with low-temperature electric drying, solar energy saved 5 cents a bushel in Indiana tests and about 2 cents a bushel in Iowa. Each 100 square feet of collecting area provided energy equal to 18.6 kilowatt-hours of electricity or 0.67 gallon of LP gas a day in eight ARS tests in Kansas.

Solar collectors are simple in construction and relatively inexpensive. Many consist of a material that transmits radiant energy, and also serves as a cover, over a dull black and perhaps roughened, corrugated, or V-shaped material that absorbs energy. Air from a fan is forced over and around the heat-absorbing surface and is warmed before entering the grain. The cover, sometimes omitted, about doubled the performance of collectors in Kansas and Iowa tests.

Many of the tests were with long, tubular plastic collectors of several types, usually air-inflated. South Dakota and Illinois engineers tested collectors installed on the side of a round grain bin. In Illinois and Wisconsin, engineers modified the roof, sidewalls, or both of a metal building near the grain bin as a collector.

For low-temperature drying, collector area has ranged from 0.10 to 0.75 square foot per bushel of grain dried. Typically, solar heat and the heat generated by the fan raise the drying temperature about 5° F with this system, Mr. Foster says.

Thirty to fifty percent of available solar heat was collected for low-temperature drying. In Ohio, a tubular collector was more efficient oriented east-west rather than north-south in November. Performance of a flat-plate collector was approximately doubled in Iowa when it was tilted toward the sun

at the optimum angle—about 50 degrees above horizontal in the Corn Belt.

Mr. Foster says drying rates with solar systems are faster than with natural air alone and usually a little slower than similar low-temperature systems with supplemental heat from fossil fuel 24 hours a day.

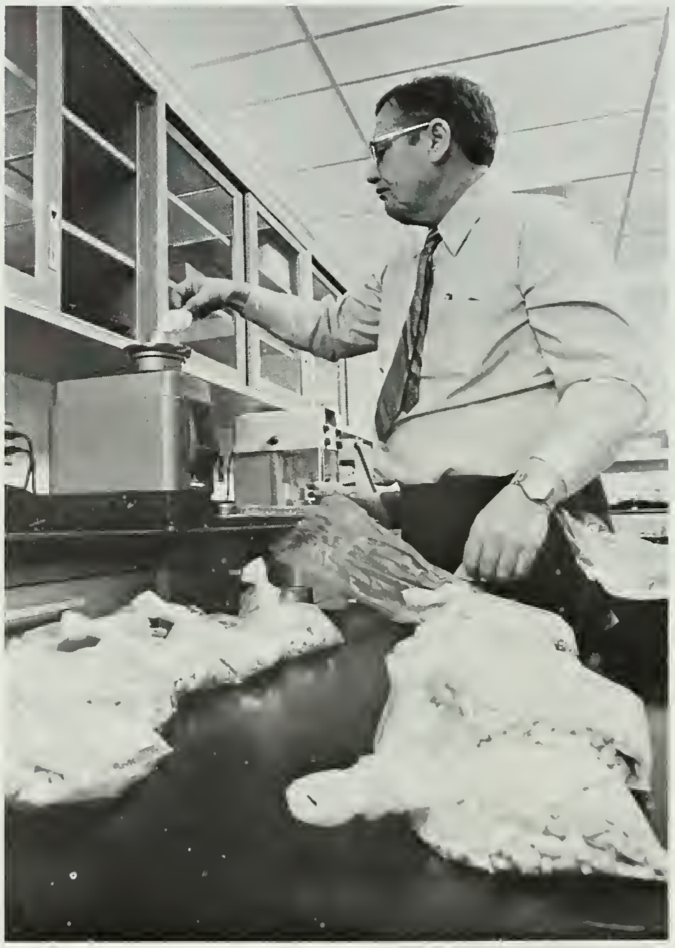
In 20 days agricultural engineers in Kansas lowered moisture content of shelled corn to 13.2 percent with solar drying and to 14.4 percent with natural air alone. In Iowa, moisture content went from 24 to 16 percent after 24 days in a solar bin, and to 14.6 percent after 16 days with continuous electric heat.

Computer simulation studies indicate the right airflow rate is the single most important requirement for success with low-temperature drying. Variations in weather from year to year can make a threefold difference in required minimum airflow. The higher the temperature or the initial moisture content of the grain, the higher the airflow rate must be to prevent spoilage.

Storing solar heat so drying will continue during the night might improve performance, Mr. Foster suggests. In preliminary tests with solar heat stored in 30 tons of rock, a flat-plate collector plus storage accomplished 15 percent more drying, with a 15 percent higher collection efficiency than a tubular collector of similar size without storage.

Multiple use of solar collectors for space and water heating as well as grain and forage drying is under study in Colorado, and Kansas engineers are testing a combination air-inflated storage, solar collector, and grain dryer. Such mutiple uses, if feasible, would reduce equipment cost charged to solar grain drying and further reduce dependence on fossil fuel.

Solar drying should be well tested and ready as a viable alternative when use of other fuels must be restricted because of decreased supply and higher costs, Mr. Foster believes.—*W.W.M.*



Top: *To determine the change in moisture content in shelled corn during solar drying, samples are periodically taken from storage bins. ISU student Robert L. Rohmiller takes a probe sample while Carl J. Bern, ISU associate professor of agricultural engineering, bottles and labels samples (0175X36–8).* ***Above:*** *Agricultural engineer Harry H. Converse weighs samples of wet grain at the U.S. Grain Marketing Research Center, Manhattan. To determine the moisture content, each sample is weighed, ovendried, and weighed again (0175X63–30).*

Mycoherbicide for Jointvetch

An endemic fungal disease, incited by a highly specific and virulent strain of the fungal pathogen *Colletotrichum gloeosporioides,* has been used successfully for the past 4 years to control northern jointvetch in Arkansas rice fields. Scientists believe the fungus can be developed as a commercial mycoherbicide to control the weed.

Large quantities of spores are applied in water suspensions with standard aerial application equipment and techniques used for chemical herbicides. The anthracnose disease, which rarely kills weeds in nature because of low natural spore density, develops rapidly and kills weeds within 1 month after treatment when spores at a concentration of 1.5 million per milliliter of water are dispersed at a rate of 94 liters per hectare.

Spores for large-scale field tests in 1975 were produced in commercial fermentors by a chemical company in Michigan. They were shipped in liquid media suspensions by air freight to Arkansas for application to weed-infested commerical rice fields.

An Experimental Use Permit and a Temporary Exemption from the requirement of establishing a residue tolerance in the harvested grain were issued by the Environmental Protection Agency for these tests. Researchers treated approximately 600 acres of rice in 1975, controlling 95 to 100 percent of the jointvetch. The weeds ranged from 41 to 68 centimeters tall. All field treatments were completed within 7 days after receiving the spores.

The research team was comprised of plant pathologist George E. Templeton and research associate David O. TeBeest at the University of Arkansas, Fayetteville, and ARS agronomist Roy J. Smith, Jr., of the University of Arkansas Rice Branch Experiment Station (P.O. Box 287, Stuttgart, AK 72160).—*P.L.G.*

Measuring movement of subsurface water

Researchers have perfected a device for measuring subsurface water movement. Called a vacuum extractor, the device is accurate to within 15 percent of actual water movement if properly operated. Previous techniques were considered good if they came within 50 percent accuracy.

Vacuum extractors provide scientists with information on movement of fertilizer and irrigation water, thus leading to improved irrigation and fertilization practices for farmers and ranchers. Once irrigation water percolates below the root zone, it is unavailable for plant growth. This wasted water also often takes fertilizers with it.

In addition, the vacuum extractors collect water so that its quality can be determined. These devices are now in use at Boulder and Greeley, Colo.; Williamsburg, Va.; and Milwaukee, Wisc., to indicate if sewage disposal sites are polluting lakes, rivers, and other water supplies.

The vacuum extractor consists of a field measuring unit and a vacuum control system. The measuring unit is a metal trough, open at the top and approximately 5 feet long. Two porous ceramic tubes are placed in the bottom of the trough. Plastic tubing connects the tubes to a collection bottle at the bottom of an access well near the trough's end.

Vacuum is applied through the collection bottle to the ceramic tubes so that water percolates into the trough at the same rate that water moves in the surrounding soil. After entering the trough, the soil water is drawn into the tubes, then drains by gravity to the collection bottle. This water can later be pumped out, measured, and analyzed.

The vacuum control system is regulated by two tensiometers, devices that measure soil water pressure. One is located in the trough, near the open top. The second is placed at the same depth, about 2 feet away. By keeping the readings on the two tensiometers approximately equal, an accurate amount of water is collected. Too much pressure collects too much water, indicating more water movement than actually exists.

To install this system, the researchers dig a trench, then bore a horizontal hole into one of its sides, 3 to 5 feet below the soil surface and below the root zone. The trough is inserted into the bore hole, then pushed upward into the undisturbed soil by inflating a rubber pillow attached to the outside bottom of the trough.

ARS agricultural engineer Harold R. Duke (360 S. Howes, Ft. Collins, CO 80521), says, "Such installation insures more accurate readings than merely digging a trench, lowering the trough into it, and covering with loose soil."

Top of the access well is at least 18 inches below the soil surface so that fields can be plowed and cultivated without any disturbance of the instruments.

One pump can supply enough vacuum to operate as many as 12 troughs, as far away as 1,200 feet.

Dr. Duke says the unit works much better on light, sandy soils than on either clay or loam. He reports that his crew of four people can install four of these units in a day.—*D.H.S.*

IGR's vs. Mosquitoes

At a time when several species of mosquitoes have developed very high levels of resistance to conventional insecticides, insect growth regulators (IGR's) offer an alternative approach to mosquito control.

Synthetic juvenile hormone analogs and other types of compounds affect the immature stages of mosquitoes by inhibiting development.

Controlling mosquitoes, for nuisance value and for disease, is a serious worldwide concern. Of the 175 or more species of Anopheles mosquitoes, one-third are carriers of malaria, endemic in parts of Central America, Mexico, Africa, and southern and southeast Asia.

In laboratory studies, ARS researchers have examined the effectiveness of 85 IGR's on the larvae of *Anopheles quadrimaculatus* Say, once a major vector of malaria in the United States. Then they conducted small plot field tests with those compounds that were found most effective.

The most promising were field tested in Lee County, Fla., where they were applied by helicopter against natural populations of the saltmarsh mosquito, *Aedes taeniorhynchus* (Wiedemann).

Of the 80 compounds tested with 4th-stage larvae, 5 proved exceptional with LC–90 values (lethal concentration necessary to kill 90 percent) of less than 0.020 parts per million (ppm), and 14 others were below 0.165 ppm.

Four of eight formulated IGR materials tested in small field plots were effective at 0.01 to 0.05 lb per acre.

Two of the most promising compounds, methoprene and TH–6040, were effective at 0.025 and 0.02 lb per acre, respectively, against natural populations that occurred in the outdoor plots after flooding.

Aerial applications of TH–6040 and methoprene were conducted during the summer on Galt Island and Sanibel Island in Lee Co. The saltmarsh mosquitoes were breeding among flooded mangroves and grasslands.

Complete control of the mosquito was obtained with 0.025 lb of TH–6040 and 0.05 lb of methoprene applied by helicopter in 5 to 10 gallons of aqueous formulation per acre.

"We made casual observations of other aquatic species and spiders, and spotchecks of nearby apiaries but we found no obvious effect on these nontarget organisms," reports ARS entomologist David A. Dame (Insects Affecting Man Research Laboratory, P.O. Box 14565, Gainesville, FL 32604).

Importantly, the insecticide-resistant strains of both the saltmarsh mosquito and *Anopheles quadrimaculatus* were as susceptible in laboratory assays to these two compounds as were nonresistant strains of the same species.

Additional studies with arylterpenoid compounds developed by ARS chemist Meyer Schwarz have revealed these materials to be even more effective than methoprene and TH–6040 in the laboratory against *Aedes taeniorhynchus*, *Anopheles quadrimaculatus*, and *Anopheles albimanus*, an important malaria vector in Central America.

In addition to Dr. Dame and Dr. Schwarz, the research team included ARS entomologist Ronald E. Lowe and technician Kenton F. Baldwin at the Gainesville laboratory, George J. Wichterman and T. Wayne Miller of the Lee County Mosquito Central District in Ft. Myers, and Angela L. Cameron with the Dept. of Entomology and Nematology at the University of Florida. —*P.L.G.*

Better charge, better pollination

Bees entering a hive after foraging deposit substantial electrical potentials on the comb surface. The hive—inside a Faraday cage with one open end to allow the bees free movement—is a standard, single-story beehive. The combs are wired with either a surface or a core attachment. This allows researchers to determine the difference in electrical potential between the surface of the comb, which is coated with a microthin layer of propolis, and the wax core. Project assistant Sue M. Weston checks weather data to determine the effect of weather on the amount of energy potential deposited in the hive (0676X797-17).

HONEY BEES entering their hive after flights on a fair summer day carry electrical charges that are more positive than charges they carry on cool, cloudy days. How well the bees get charged up may have a bearing on how well they do their job of pollinating more than 100 agricultural crops.

Measuring electrical potentials (charges) of worker bees between 7 a.m. and 6 p.m., ARS entomologist Eric H. Erickson (Dept. of Entomology, University of Wisconsin, Madison, WI 53706), found that as bees left the hive, their potentials normally were slightly negative to earth ground early in the day and turned slightly positive as the day advanced.

As bees fly they may acquire positive potentials, says Dr. Erickson. He found that bees returning to the hive had positive voltages—up to 1.5 volts d.c.—on bright, warm days with low humidity, and the peak voltages occurred at midday or early afternoon.

Scientists have also learned that some plant species, under fair weather conditions, have negative potentials that become greatest at midday. Do these phenomena influence the bees' choices of flowers to visit? Dr. Erickson is trying to find out whether environmental electricity serves as a behavioral stimulus for bees' pollination and foraging.

The difference in electrical potential between flower and bee may cause pollen transfer when the bee comes close to but does not actually touch the male part of the lossom, says Dr. Erickson. And besides possibly increasing pollination efficiency, the electrical phenomena may be components of learning as bees communicate.

Dr. Erickson has evidence that intensities of electrostatic charges that bees acquire, as they return to the hive, are influenced by both the distance they fly and solar radiation. A daily cycle of changes in solar radiation is related to a daily cycle of changes in positive electrical potentials on the bees. Early in his studies, Dr. Erickson measured these potentials during a partial eclipse of the sun and found that they were less intense than during the same time on other days with similar weather.

Worker bees become irritable when the air is highly charged with electricity, according to observations of other researchers. Scientists also have found that bees' electrostatic charges increase during periods of atmospheric electrical activity before storms. —*G.B.H.*

One method used to indicate bees' sensitivity to electricity is the application of electrical potential to the propolis. As Dr. Erickson applies the charge, bees will exhibit a range of response patterns from no response to aggressiveness, depending on the weather (0676X 796-6).

AGRISEARCH NOTES

Biological control of mesquite

A PLANT that should be familiar to everyone from the more desolate scenes in Western movies is also a serious pest infesting 50 million acres of rangeland in Texas as well as parts of New Mexico and Arizona.

Still expanding its range from the early days when it moved with settlers' cattle out of isolated arroyos, mesquite is a drought-hardy, woody legume that has deep roots and can withstand long periods of drought—but it also uses great quantities of water when it is available. In fact, it has been known to dry up springs and waterholes, so voracious is its thirst, and thus deprive cattle and range grass of needed water.

Currently, ranchers attempt to control mesquite with chemicals without complete success.

Searching for a possible biological control, ARS entomologist Charlie E. Rogers (Southwestern Great Plains Research Center, Bushland, TX 79012), conducted a 3-year study of an insect that girdles the branches of the mesquite plant.

The adults of the twig girdler chew around the branches, mostly during middle and late September, killing the stems and branches and laying eggs in the dying tissue. The eggs hatch, the larvae develop into more adults, and the girdling goes on.

While the twig girdler shows some promise as a possible biological control, the main problem is that it is a native species and thus subject to many natural enemies.

Dr. Rogers feels that a similar insect imported from abroad that would be more free from natural parasites and predators might be more effective to help control an increasingly troublesome pest that costs ranchers heavy investments each year in time, effort, and money.—*B.D.C.*

Nature's boosters

NATURE has provided us with fungal allies that we have ignored rather than supported for far too long. The fungi are called mycorrhizae and if ARS is successful in utilizing these biological boosters, the amount of fertilizers needed to obtain good, healthy plants may be significantly reduced. The incidence or severity of root diseases may be decreased, providing an added benefit.

Most fertilizers are derived from fossil fuels. Any reduction in the amount of fertilizer needed to grow a crop would be an important contribution to energy conservation.

Mycorrhizae under study are fungi that live in a symbiotic state in plant roots. It is abnormal for most plants not to have mycorrhizae, and most plants on the earth do.

The relationship between the mycorrhizal fungi and the host plant is beneficial to both, and many researchers feel that the relationship is essential to the host plant's survival and well-being. Yet we currently suppress the mycorrhizae by overfertilization. Also, fumigation with pesticides, designed to kill undesirable fungi, kills desirable fungi as well.

ARS plant pathologist Robert Linderman, at the Ornamental Plants Research Laboratory (1057 Cordley Hall, Oregon State University, Corvallis, OR 97331), hopes to learn how to gradually "ease back on fertilizers and ease in mycorrhizae."

Currently Dr. Linderman and his staff are characterizing the mycorrhizae which occur on a range of ornamental plants. They are studying how these fungi enhance plant growth by increased nutrient uptake, how they enhance root proliferation, how diseases of the host plant are affected, how much the amount of fertilizer needed by the host plant might be reduced, and whether mycorrhizae can effectively reduce the effects of environmental stresses.

Mycorrhizae are grouped in three major types, based on the way the fungus infects its host roots. All three types have an extensive network of hyphal strands that extend into the soil away from the root. These strands function as an extended root system for the host plant and greatly increase the plant's ability to gather in water and nutrients. In addition, some mycorrhizae also increase the host plant's ability to store nutrients and to ward off attacks from pathogens.

In several ways, then, the mycorrhi-

zae work to increase the host plant's efficiency. A more efficient plant needs less fertilization because it wastes less of the nutrients made available to it. Moreover, with mycorrhizae at work, cuttings of plants that are difficult to root become much easier to root.

It may be 10 years before mycorrhizae are understood enough to be used by growers on a large scale to enhance growth and adaptability of plants, but at least the groundwork is well underway.—*L.C.Y.*

Let them eat viruses

OUR SUN'S LIGHT makes possible all life on earth, and primitive people were not wrong to regard it as a father—and like an earthly father, it punishes as well as sustains: remember those blisters from a dazzling day on the beach?

The same radiation that caused those blisters also cuts the effectiveness of one of science's most promising biological controls of insect pests—a virus, harmless to man, that can be used to eliminate large numbers of bugs, among them the notoriously destructive pests of cotton, the bollworm and tobacco budworm.

Now, by protecting the nuclear polyhedrosis virus from sunlight that rapidly inactivates it, scientists are able to achieve biological control of bollworms and budworms that approaches the control given by chemical insecticides.

The trick is to encapsulate the virus in a digestible substance that protects it from the sun's ultraviolet rays until the caterpillars eat it. The virus then attacks the bugs from within, causing death and disintegration and further releasing large quantities of virus. Other caterpillars consume the increasingly more abundant virus, thus setting off an epidemic.

In tests conducted with the Southwest Research Institute, ARS entomologists Don L. Bull (Cotton Insects Research Laboratory, College Station, TX 77840) and Richard L. Ridgway (National Program Staff, Beltsville, MD 20705) found that two commonly available materials were effective as encapsulating screening agents: carbon black and titanium dioxide.

These formulations increased the killing power of the virus over unprotected virus by preserving effective biological activity for several days in the field. They also enabled the virus to withstand long exposure directly beneath germicidal and blacklight lamps in laboratory tests.

A further encouraging aspect of the encapsulated virus is that it can be used with conventional application equipment.

Future research will be directed toward improving the encapsulated formulations. For instance, the present formulations probably provide protection from sunlight far beyond what is actually needed in practical application. The scientists will also try to find "gustatory-stimulants" to incorporate into the formulations, that is, to create an irresistible and fatal gourmet treat for the pests. *Bon appétit*, bug!—*B.D.C.*

UHF energy destroys weed seeds

JOHNSONGRASS, a prolific weed found in many farm fields, may someday be brought to account by electromagnetic energy being tested in the laboratory. ARS scientists Robert Menges (P.O. Box 267, Weslaco, TX 78596) and Rex Millhollon (P.O. Box 470, Houma, LA 70360) placed water-soaked and unsoaked Johnsongrass seeds in test tubes partially filled with air-dry sandy loam soil. The seeds were exposed to 45 and 90 joules per cubic centimeter (J/cm^3) of Ultra-High Frequency Electromagnetic energy. The control group was unexposed. Maximum soil temperatures were 59°C at 45 J/cm^3 and 94°C at 90° J/cm^3. The seeds were maintained for 6 months at 20° to 35°C with a daily exposure of 8 hours light and 16 hours dark.

Percentages of seeds germinating or decaying were recorded weekly. After 6 months 44 percent of the unexposed seeds germinated, 29 percent did not germinate, and 27 percent decayed. The seeds exposed to 90 J/cm^3 of Ultra-High Frequency energy were nearly all decayed, regardless of whether they were soaked. At 45 J/cm^3 unsoaked seeds were not affected, but 73 percent of the soaked seeds were decayed.

Although further studies will be done, these preliminary data indicate that UHF energy affected the germination capability of dormant Johnsongrass seeds. Exposure to UHF energy caused injury sufficiently severe to allow decay of the seeds.—*E.L.*

Carrot juice for breakfast

AN estimated 20,000 to 24,000 tons of carrots fail to meet market quality standards and are discarded each year in the South Texas area alone. Concerned about this colossal waste of resources, ARS scientists Guadalupe Saldana, Thomas S. Stephens, and Bruce J. Lime, of the Food Crops Utilization Research Laboratory (P.O. Box 388, Weslaco, TX 78596), set out in search of a remedy.

Beverages were prepared from combinations of carrot juice, carrot puree, whole orange puree, grapefruit and pineapple juices, lemon juice concentrate, sugar, citric and ascorbic acids, and artificial pineapple and orange flavors.

The beverages were stored at 20°C (68°F) for 9 months. An analysis of the pH, acid, Brix (sugar percentage), B-carotene, ascorbic acid, color, and flavor was made at 0, 1, 2, 4, 6, and 9 months. The major nutrient lost during processing and storage was ascorbic acid (vitamin C). The juice may, however, be enriched with vitamin C. Storage had no effect on other quality factors.

A taste panel consistently rated the carrot-orange puree plus pineapple juice as the beverage with the most desirable flavor. Plain carrot juice had the least desirable flavor. While carrot juice has not yet replaced orange juice for breakfast, it may one day have a crack at it.—*E.L.*

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